

CLAIMS

What is claimed:

1. A programmable material consolidation apparatus, comprising:
a support element;
a selective material consolidation system configured to form an object on at least one of the support element and a substrate positioned on the support element;
a machine vision system oriented to view the support element and an object under fabrication, the machine vision system including a field of vision which is at least substantially coextensive with a field of exposure of the selective material consolidation system; and
at least one control element in communication with the selective material consolidation system and the machine vision system.
2. The programmable material consolidation apparatus of claim 1, wherein the machine vision system includes a locationally stationary camera positioned to avoid interference with the selective material consolidation system.
3. The programmable material consolidation apparatus of claim 2, wherein the locationally stationary camera comprises a charge-coupled device.
4. The programmable material consolidation apparatus of claim 2, further comprising:
a magnification element associated with the locationally stationary camera to magnify an image viewed thereby.
5. The programmable material consolidation apparatus of claim 4, wherein the magnification element optically magnifies the image.

6. The programmable material consolidation apparatus of claim 4, wherein the magnification element digitally magnifies the image.

7. The programmable material consolidation apparatus of claim 2, wherein the machine vision system further includes a rotational element associated with the locationally stationary camera to facilitate orientation of the locationally stationary camera to a selected location the field of exposure.

8. The programmable material consolidation apparatus of claim 1, wherein the machine vision system includes:

a scan element; and

a camera configured to view a portion of the field of exposure and carried by the scan element, the scan element being configured to move the camera to a plurality of locations over the field of exposure.

9. The programmable material consolidation apparatus of claim 8, wherein the scan element positions the camera proximate to a location in which selective material consolidation is to be effected.

10. The programmable material consolidation apparatus of claim 9, wherein the camera has an image resolution of about 0.0001 inch.

11. The programmable material consolidation apparatus of claim 8, wherein the camera comprises a charge-coupled device or a complementary metal-oxide-semiconductor device.

12. The programmable material consolidation apparatus of claim 8, wherein the scan element includes:

an x-axis element; and

a y-axis element oriented substantially perpendicular to the x-axis element.

13. The programmable material consolidation apparatus of claim 12, wherein the camera is positioned at a location where the x-axis element and the y-axis element intersect one another.

14. The programmable material consolidation apparatus of claim 12, further comprising an actuator associated with each of the x-axis element and the y-axis element.

15. The programmable material consolidation apparatus of claim 14, wherein each actuator is configured to move its associated x-axis element or y-axis element incrementally.

16. The programmable material consolidation apparatus of claim 14, wherein each actuator is configured to move its associated x-axis element or y-axis element substantially continuously.

17. The programmable material consolidation apparatus of claim 14, wherein operation of each actuator occurs under control of the at least one control element.

18. The programmable material consolidation apparatus of claim 1, wherein the at least one control element receives signals from the camera indicating locations of features on or over the support element.

19. The programmable material consolidation apparatus of claim 18, wherein the at least one control element is configured to cause the selective material consolidation system to effect fabrication of one or more objects at a precise location on at least one of the support element and a substrate thereon based on a location of at least one feature viewed by the machine vision system.

20. The programmable material consolidation apparatus of claim 1, further comprising:

at least one fiducial mark associated with the support element for providing a reference point for the machine vision system.

21. A programmable material consolidation apparatus, comprising:
a support element;
a selective material consolidation system configured to form an object on at least one of the support element and a substrate positioned on the support element;
a machine vision system oriented to view the support element and an object under fabrication thereon, the machine vision system including:
a locationally stationary camera positioned to avoid interference with the selective material consolidation system; and
at least one control element in communication with the selective material consolidation system and the machine vision system.

22. The programmable material consolidation apparatus of claim 21, wherein the machine vision system includes a field of vision which is at least substantially coextensive with a field of exposure of the selective material consolidation system.

23. The programmable material consolidation apparatus of claim 21, wherein the locationally stationary camera comprises a charge-coupled device.

24. The programmable material consolidation apparatus of claim 21, further comprising:
at least one fiducial mark associated with the support element for providing a reference point for the machine vision system.

25. The programmable material consolidation apparatus of claim 21, further comprising:
a magnification element associated with the locationally stationary camera to magnify an image viewed thereby.

26. The programmable material consolidation apparatus of claim 25, wherein the magnification element optically magnifies the image.

27. The programmable material consolidation apparatus of claim 25, wherein the magnification element digitally magnifies the image.

28. The programmable material consolidation apparatus of claim 21, wherein the machine vision system further includes a rotational element associated with the locationally stationary camera to facilitate orientation of the locationally stationary camera to a selected location the field of exposure.

29. The programmable material consolidation apparatus of claim 21, wherein the at least one control element receives signals from the locationally stationary camera indicating locations of features on or over the support element.

30. The programmable material consolidation apparatus of claim 29, wherein the at least one control element is configured to cause the selective material consolidation system to effect fabrication of one or more objects at a precise location on at least one of the support element and a substrate thereon based on a location of at least one feature viewed by the machine vision system.

31. A programmable material consolidation apparatus, comprising:
a support element;
a selective material consolidation system configured to form an object within a field of exposure on at least one of the support element and a substrate positioned on the support element;
a machine vision system oriented to view the support element and an object under fabrication thereon, the machine vision system including:
a scan element; and

a camera configured to view a portion of the field exposure and carried by the scan element, the scan element being configured to move the camera to a plurality of locations over the field of exposure; and
at least one control element in communication with the selective material consolidation system and the machine vision system.

32. The programmable material consolidation apparatus of claim 31, wherein the machine vision system includes a field of vision which is at least substantially coextensive with the field of exposure of the selective material consolidation system.

33. The programmable material consolidation apparatus of claim 31, wherein the scan element positions the camera proximate to a location in which selective material consolidation is to be effected.

34. The programmable material consolidation apparatus of claim 31, wherein the camera has an image resolution of about 0.0001 inch.

35. The programmable material consolidation apparatus of claim 31, wherein the camera comprises a charge-coupled device.

36. The programmable material consolidation apparatus of claim 31, further comprising:
at least one fiducial mark associated with the support element for providing a reference point for the machine vision system.

37. The programmable material consolidation apparatus of claim 31, wherein the at least one control element receives signals from the camera indicating locations of features on or over the support element.

38. The programmable material consolidation apparatus of claim 37, wherein the at least one control element is configured to cause the selective material consolidation system to effect fabrication of one or more objects at a precise location on at least one of the support element and a substrate thereon based on a location of at least one feature viewed by the machine vision system.

39. The programmable material consolidation apparatus of claim 31, wherein the scan element includes:

- an x-axis element; and
- a y-axis element oriented substantially perpendicular to the x-axis element.

40. The programmable material consolidation apparatus of claim 39, wherein the camera is positioned at a location where the x-axis element and the y-axis element intersect one another.

41. The programmable material consolidation apparatus of claim 39, further comprising an actuator associated with each of the x-axis element and the y-axis element.

42. The programmable material consolidation apparatus of claim 41, wherein each actuator is configured to move its associated x-axis element or y-axis element incrementally.

43. The programmable material consolidation apparatus of claim 41, wherein each actuator is configured to move its associated x-axis element or y-axis element substantially continuously.

44. The programmable material consolidation apparatus of claim 41, wherein operation of each actuator occurs under control of the at least one control element.